Meiji University Global COE Program

34th Mathematical Sciences based on Modeling, Analysis and Simulation seminar

Date: December 20, 2010, 16:30～18:00

Location: Meiji Univ. Ikuta Campus, Build 2 Annex A, Room A310

Masashi Aono (RIKEN)

Title : Amoeba-based Neurocomputing: Spatio-Temporal Dynamics for Overall Optimization in Resource Allocation and Decision Making

Abstract :A single-celled amoeboid organism, the true slime mold Physarum polycephalum, exhibits rich spatiotemporal oscillatory behavior and sophisticated computational capabilities. Our aim is to clarify how the organism achieves the "overall optimization," the maximization of the benefit of the whole body, which cannot always be realized by simply summing selfish behaviors of the organism's components pursuing their partial interests. We created a biocomputer that incorporates the organism as a computing substrate to search for solutions to various optimization problems with the assistance of optical feedback to implement recurrent neural network models. The organism changes its shape by alternately growing and withdrawing its photosensitive branches so that its body area can be maximized and the risk of being illuminated can be minimized. In this way, the organism succeeded in finding the optimal solution to the four-city Traveling Salesman Problem with a high probability. Considering the organism as a network of dynamical systems that compete for constant amounts of intracellular resources, we formulated two mathematical models to extract essential dynamics of the amoeba-based computing. 1) Resource-Competing Oscillator Network (RCON) model is an ordinary differential equation model of a particular kind of coupled oscillators. RCON model reproduces well the organism's experimentally observed behavior, as it generates a number of spatiotemporal oscillation modes and spontaneous switching among the different modes. 2) Tug-Of-War (TOW) model is a star network of discrete-time-state dynamical systems capable of efficient and adaptive decision making in solving the Multi-armed Bandit Problem (MBP), a problem of finding the most rewarding one from a number of probabilistic slot machines. TOW model exhibits better performances compared with well-known algorithms for MBP. In our models the resource conservation law seems to play important roles for the efficient and adaptive computation, as it leads the amoeba-like branches to perform spatiotemporally correlated parallel search.

Everyone is welcome to attend the MAS seminar.

Meiji institute for Advanced Study of Mathematical Science (http://www.mims.meiji.ac.jp)
(Organizers: M. Mimura, D. Ueyama, Y. Wakano, K. Ikeda and S.Kinoshita)

MAS seminar is partly supported by Meiji University Global COE program "Formation and Development of Mathematical Sciences Based on Modeling and Analysis" (http://gcoe.mims.meiji.ac.jp/), the Grant-in-Aid for Scientific Research (S), "Mathematical Theory of Nonlinear-Non-equilibrium Reaction-Diffusion Systems" by M. Mimura (http://nnrds.math.meiji.ac.jp/).

Access: 10 minutes on foot from Ikuta St. Odakyu line,
Or 10 minutes by bus No. 13「明治大学正門前」, get off at the last stop.
See http://www.meiji.ac.jp/koho/campus_guide/ for details.